Energy & Sports Nutrition

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Energy for Sport

Very High Intensity
Weight- and Body- Focused
Intermittent, High-Intensity
History of Sport Energy Research

• 1920

XXX. THE RELATIVE VALUE OF FAT AND CARBOHYDRATE AS SOURCES OF MUSCULAR ENERGY.
WITH APPENDICES ON THE CORRELATION BETWEEN STANDARD METABOLISM AND THE RESPIRATORY QUOTIENT DURING REST AND WORK.

By AUGUST KROGH and JOHANNES LINDEHARD.
WITH THE COLLATION OF
OHRAN LILJEBERG and KVIG OAD ANDERSEN.
From the Laboratory of Zoophysiology, Copenhagen University.
(Renewed August 1909, 1913.)

• 1960’s and 1970’s
  ○ Bergstrom ad Hultman “Supercompensation” and the effects of dietary CHO, FAT, PRO manipulation
• Current....

Energy Systems Overview

Metabolism Summary

Proteins
- amino acids

Carbohydrates
- glucose, fructose, galactose

Glycogen

Glucose-6-Phosphate

Pyruvic Acid

Lactate

Acetyl CoA

Citric Acid Cycle

CO₂

Urea Cycle

CO₂

NH₃

Nitrogen Pool

Fats and Lipids
- fatty acid oxidation

Lipogenesis

Fatty Acid Spiral

Electron Transport Chain

O₂

ADP

ATP

H₂O

http://www.humpath.com/fatty-acid-oxidation-diseases
Energy Systems

Figure 1: Energy systems activity as a function of time and capacity (adapted from Verheijen, 1998)


High-Intensity, Short Duration Sports

- **Examples of Sport Activities:**
  - run/swim/cycle sprints, jumps, discus throws, hurdles, pole-vaulting
  - Events lasting from seconds to minutes

- **Primary energy systems:**
  1. **High Energy Phosphate System** (ATP-PC)
     - (Up to 15 seconds)
  2. **Anaerobic Glycolysis System**
     - (15 seconds-3 minutes)
High-Energy Phosphate System

PCr = Phosphocreatine
CK = Creatine kinase
Pi = Inorganic Phosphate Molecule
ADP = Adenosine Diphosphate
ATP = Adenosine Triphosphate

High Energy Phosphate System

- Phosphocreatine (PCr) is the most rapidly accessible form of energy “storage.”
- The reaction:
  1. Creatine kinase (CK) catalyzes the reaction
  2. Phosphocreatine (PCr) releases inorganic phosphate molecule (Pi)
  3. __________ combines with ADP to form ATP.

- ATP is used for energy
ATP and Energy

- How is energy produced from ATP?
  - Energy is released when ATP is broken through hydrolysis, forming ADP and an inorganic phosphate molecule (Pi).

  \[
  \text{ATP} \rightarrow \text{ADP} + \text{Pi}
  \]

  - The released energy is 9-10 kcals per mole of ATP.

Anaerobic Glycolysis System

- One molecule of glucose yields 2 ATP and 2 pyruvate

- With no oxygen (anaerobic pathway), the 2 pyruvate molecules convert into 2 lactate molecules

  \[
  \text{Glucose} \rightarrow \text{pyruvate} \xrightarrow{\text{anaerobic}} \text{lactate}
  \]

- Time frame: > 15 seconds until < 3 minutes
- Lactate production ↑ as intensity of workout ↑
Anaerobic Glycolysis

- 1 glucose yields 2 ATP

![Diagram of Anaerobic Glycolysis](http://webanatomy.net/anatomy/glycolysis.jpg)

Study: Energy System Contribution to 400-m and 800-m track running

- 400-m: 11 males, 5 females
- 800-m: 9 males, 2 females

- Lab-graded exercise tests; multiple race trials (simulated event treadmill running)

- Based on VO2, Accumulated Oxygen Deficit (AOD) measures, blood lactate concentrations (lactate/PCr)
Results

- AOD/PCr showed significantly larger anaerobic energy contribution in the 400-m trials compared to the 800-m trials

- anaerobic glycolysis system contribution:
  - About 60% for 400m events
  - About 35% for 800m events.

Energy Needs: Very High Intensity Sports

- Energy needs may be adjusted according to the individual.

- **CHO**: 5-6 g/kg body wt. daily
  - Necessary to replenish glycogen stores

- **Protein**: 1.2-1.7 g/kg body wt daily
  - Necessary to help to build and maintain muscle mass, which is important for high intensity sports

- **Fat**: 1 g/kg body wt daily
  - Provides energy to support high training demands
Dietary Supplements & Ergogenic Aids

• Creatine- Most commonly used aid for high intensity, short-duration sports

• Belief: Creatine supplementation will increase PCr stores, giving Athletes more energy
  ▫ True or False?
    • Debatable
    • Many research studies display opposing results
    • What do you think??

Endurance Athletics

• Endurance Sports:
  ▫ Marathon run/swim
  ▫ Ironman & varying distance triathlon
  ▫ long periods of time at low intensity

• Energy Systems Used:
  ▫ Carbohydrate during warm up
  ▫ Aerobic $B$-oxidation fat metabolism
  ▫ $<65\%\ V_O^{2max}$ Combination of both
Aerobic Glycolysis

- 1 glucose yields 38 ATP

Illustration source: http://www.nature.com/pcan/journal/v9/n3/images/4500879f1.jpg

Beta-Oxidation

Illustration source: http://www.nature.com/pcan/journal/v9/n3/images/4500879f1.jpg
Synergy in Energy Supply

- “Intensity has a major impact on the fraction of fat oxidized.” (Stisen et al 2006)

- Female fat usage study correlates energy use to all exercise intensity

- *Maximal fat oxidation rates in endurance trained and untrained women*

- Anne Bach Stisen · Ole Stougaard · Josef Langfort · Jørn Wulv Helge · Kent Sahlin · Klavs Madsen

Following Images from Stisen et al report
Energy Needs for Endurance Athletes

- Carbohydrate
  - 7 to 10 g/kg body weight

- Protein
  - 1.2 to 2.0 g/kg body weight

- Fat
  - Increased slightly from 0.8 to 2.0 g/kg body weight

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Fig. 1 Fat oxidation versus absolute power output (watt) between trained and untrained women. Values are means ± SE of nine untrained and eight trained women. *Significantly different from untrained, $P < 0.05$
Fluid Timing

- **Before**
  - Drink 17 to 20 oz 2 hours before event
  - Drink 7 to 10 oz 10 to 20 minutes before event
- **During**
  - Drink 7 to 10 oz every 15 to 20 minutes, including sodium
- **After**
  - Drink 20 to 24 oz sport drink every pound body weight, including sodium

Improved Endurance Capacity Following Chocolate Milk Consumption Compared to two commercially available sport drinks

- Thomas, K., Morris, P., Stevenson, E. (2009)
Carbohydrate and Protein + 30 min.

Intermittent Sports

Refers to activities that require short periods of all-out effort punctuated with periods of less intense effort.

<table>
<thead>
<tr>
<th>Team Sports</th>
<th>Individual Sports</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Soccer</td>
<td>✓ Tennis</td>
</tr>
<tr>
<td>✓ Football</td>
<td>✓ Squash</td>
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<tr>
<td>✓ Basketball</td>
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<tr>
<td>✓ Field Hockey</td>
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<tr>
<td>✓ Rugby</td>
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<tr>
<td>✓ Volleyball</td>
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Varying intensities and durations tap ALL major energy systems.
Intermittent Nutrition

**Macronutrients...**

Carbohydrates are the preferred fuel for stop-and-go sports...

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Carbohydrates

- Diets low in carbohydrates (<10% total energy from carbs) = reduced endurance time.
- Diets providing 65-84% of total energy = increased performance.
- Maughn et al noted that a high protein (particularly in conjunction with a low carb diet) resulted in metabolic acidosis- associated with fatigue.
Muscle Glycogen

- Bangsbo et al reported increasing carb content from 39-65% prior to a soccer match caused muscle glycogen levels to increase.
- This results in higher work rate and improved intermittent endurance.
- Glycogen depletion potentially contributes to fatigue, limiting the ability to maintain high intensity work output.
- Without sufficient muscle glycogen, exercise is fueled by fat. Intensity of that exercise is usually less than 50% capacity.

Blood Glucose

- May spare muscle glycogen...
- As exercise duration increases, carbs from muscle glycogen decrease and those from blood glucose increase.
- Hypoglycemia & depletion of glycogen are associated with fatigue & reduced performance.
Protein

- If amino acids are not replaced in the diet, a net loss occurs over time with losses in muscle strength and performance.
- Excessive protein intakes can lead to health hazards.
- There is a lack of evidence to show that an addition of protein increases performance.

Fat

- Plays the smallest role in energy distribution.
- Fat should contribute to 30% or less of total energy.
- Athletes often consume levels of fat to support weight and weight training goals, but this consumption should be limited.
Fluids

- Major causes in fatigue are due to thermoregulation and fluid loss.
- Repletion of muscle glycogen also relies on fluid intake—each gram is stored with 2.7 grams of water.
- Full rehydration after exercise is best achieved when replacement fluid contains sufficient sodium and is consumed at 150% of fluid lost during exercise. (Shirreffs et al)

Study: Carbohydrate Availability and Muscle Energy Metabolism during Intermittent Running

Purpose: To investigate the effects of ingesting a CHO-E solution on performance and muscle glycogen use during prolonged intermittent high intensity running to fatigue in carbohydrate-loaded men.

Results

- All subjects ran longer during the CHO-E trial compared with the PLA trial by 21%.
- Study shows for the first time CHO-E during exercise leads to an improvement in high intensity intermittent running capacity, but did not affect muscle glycogen use.
- Subjects with high pre-exercise muscle glycogen as a result of dietary CHO loading, the solution of 6.4% CHO-E used immediately before and during exercise can increase endurance capacity.

Weight & Body-focused Sports

Examples of Sport Activities:
- figure skating
- gymnastics
- Wrestling

Energy Systems
- Adenosine triphosphate - creatine phosphate energy system (ATP-PC) 70%-90%
  - high-intensity muscular work
- Aerobic Glycolysis System 10%-30%
  - quick recovery
  - low-to medium-intensity activity
Energy needs
for weight & body focused sports

- **Carbohydrate**
  - primary fuel of athletes
  - 5 to 8 g/kg body weight, daily

- **Protein**
  - stimulate muscle protein synthesis
  - promote performance
  - 1.2 to 1.7g/kg body weight, daily

- **Fat**
  - individual nutritional demand
  - for the various normal physiological functions
  - 20% to 35% is recommended

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Meal-Planning Recommendations

- **Before the event**
  - high in carbohydrate  low in protein  &  fat  foods

- **Between event**
  - water or sport drink
  - easily digestible carbohydrate foods

- **After the event**
  - sport drinks
  - fruit juices
  - carbohydrate-containing fluids
Study: Cereal and nonfat milk support muscle recovery following exercise


Recovery

- Within the first 30 minutes

- Carbohydrate and Protein in a ratio: 3 -4 to 1

  Similar to Chocolate milk!!!
Human Ecological Model

- **Microsystem**: Athletes influenced by coaches, family, and friends
- **Exosystem**: Athletes influenced by the community, the school that the athlete is representing, and media within the community
- **Macrosystem**: Athletes affected by rules and regulations, politics, culture, and the society as a whole

**References**


References (Cont’d)


